

REMARKS

Reexamination and reconsideration of this application in view of the present response with amendment is kindly requested. By this amendment, Claims 7, 10, and 12, were amended, and new dependent Claim 40 was added. After this response with amendment, Claims 1-15 and new Claim 40 remain pending in this application.

Objection to the Specification

The Examiner objected to the title of the invention as not being descriptive of the currently claimed invention. In particular, the Examiner suggested amending the title to reflect the method to which the claims are directed to.

Accordingly, Applicants have amended the title of the invention to

***PROCESS FOR PRODUCING A LAYER OF TANTALUM
PENTOXIDE ON A CARRIER MATERIAL***

which Applicants believe is descriptive of the claimed invention. Therefore, Applicants kindly request that the Examiner withdraw the objection to the title of the invention.

Claim Rejections - 35 USC § 112

The Examiner rejected Claims 1-15, under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter of the invention. Specifically, Claim 7 was rejected because a claim limitation including two ranges was considered vague and indefinite. Further, Claim 10 was rejected because the Examiner concluded that "titanium nitride" and "tantalum nitride", and nitrides in general, are not metallic materials.

Applicants have amended Claim 7, and added new Claim 40, only to separate the two ranges into two dependent claims. This should help make amended Claim 7, and new Claim 40, recite the two ranges more clearly and definitely. This correction of the claim language was made to help more clearly recite the invention, and not for patentability or to further limit the claims in view of any prior art. No new matter was added by these amendments.

Also, only to advance prosecution, Applicants have amended Claims 10 and 12 to, first of all, make these claims depend directly from independent Claim 1, and further to recite that the carrier material is chosen from the group of materials listed in each respective dependent claim. No new matter was added by the amendments.

Note also that in the semiconductor industry titanium nitride and tantalum nitride in certain applications are recognized as metallic materials. Titanium nitride, for example, is also known as a conductive barrier, or a "barrier metal", while it is understood that this material is typically chemically considered a ceramic. Such metallic materials can be used to form the metallic electrodes of a capacitor in an integrated circuit. See also the discussion in the specification, on page 9, line 23, to page 10, line 2.

A **barrier metal** is a material used in integrated circuits to chemically isolate semiconductors from soft metal interconnects, while maintaining an electrical connection between them. For instance, a layer of barrier metal must surround every copper interconnection in modern copper-based chips, to prevent diffusion of copper into surrounding materials. Some materials that have been used as barrier metals include cobalt, ruthenium, tantalum, tantalum nitride, indium oxide, and titanium nitride (the last three being conductive ceramics, but "metal"s in this context). See online Wikipedia reference encyclopedia at http://en.wikipedia.org/wiki/Barrier_metal.

Therefore, in view of the amendments and discussion above, Applicants believe that the rejection of Claims 1-15, under 35 U.S.C. 112, second paragraph, has been overcome. Applicants request that the Examiner withdraw the rejection of these claims.

Claim Rejections - 35 USC § 103

The Examiner rejected Claims 1-15, under 35 U.S.C. 103(a) as being unpatentable over Vaartstra, U.S. Patent No. 6,784,049, or Hintermaier, U.S. Patent No. 6,787,186, or Senzaki et al., U.S. Patent No. 6,616,972.

Applicants have amended Claims 7, 10, and 12, and added new dependent Claim 40, to more clearly and distinctly recite the present invention, and not for patentability or to further limit the claims in view of any prior art.

Applicants respectfully traverse the Examiner's rejection of Claims 1-15 under 35 U.S.C. 103(a). Applicants respectfully assert that Vaartstra, Hintermaier, Senzaki, or any combination thereof, do not teach, anticipate, or suggest, inter alia,

heating carrier material to a heating temperature of between approximately 200°C and 400°C; and

circulating a gas mixture comprising tert-butyliminotris (diethylamino) tantalum ($\text{t-BuN}=\text{Ta}(\text{NEt}_2)_3$) in contact with the heated carrier material under an oxidizing atmosphere thereby forming a layer of tantalum pentoxide (Ta_2O_5) on the carrier material, the partial pressure of the tert-butyliminotris (diethylamino) tantalum being greater than or equal to 25 mTorr,

as recited for independent Claim 1, and for all dependent claims depending therefrom. Moreover, neither of these references nor any combination thereof teaches or suggests a vapor phase deposition process of tantalum pentoxide from TBTDET organometallic precursor at low temperature, under high TBTDET partial pressure allowing the deposition of good quality

tantalum pentoxide layers

Overview of VAARTSTRA US6,784,049

Vaartstra describes a vapor phase deposition process to form a refractory metal oxide layer, preferably tantalum pentoxide. The precursor used is a tantalum halogen compound along with some ether compound. The CVD deposition process is shortly described, but stress is put on atomic layer deposition process. The features of such a deposition process is a deposition rate of 0.4-15 Å/s within a temperature range of 200-500°C and within a pressure range of .01-10 Torr. The layer obtained with such a process is a few hundreds Angstroms thick and must be annealed at 400-1000°C for 0.5-60 min.

Overview of SENZAKI US6,616,972

Senzaki discloses a vapor phase deposition process for tantalum oxide. The precursor is an organometallic compound with the following formula $(R^1R^2N)_xM(=NR^3)_y$ or $(R^4R^5N)_xM[O^2-R^6N=C(R^7)(R^8)]_y$. The deposition process is performed, among other possible process, by chemical vapor deposition within 200-600°C and under a pressure within the 0.5-1.5 Torr range with an atmosphere containing nitrogen and oxygen. The deposition rate is 1.7 Å/s and requires annealing at 800°C for 30 min.

Overview of HINTERMAIER US6,787,186

Hintermaier discloses a vapor deposition process for tantalum oxide deposition. The precursor is $Ta(OiPr)_4(thd)$ in a system of organic solvents. Vapor phase deposition occurs at 150-800°C under a pressure of 0.5-20 Torr in an oxidizing atmosphere in the presence of an additive compound for facilitating the thermal decomposition of the precursor compound. No specific deposition rate is given for tantalum oxide deposition, yet the document deals with the deposition of several different refractory metals and the only deposition rate given is the one for bismuth oxide with a speed of 0.5-0.9 Å/min.

Analysis Of The Present Claims In View Of VAARTSTRA, HINTERMAIER, or SENZAKI

First of all, the Examiner has recognized in the Office Action that the TBTDDET precursor is neither used nor suggested by any of the three cited documents.

Concerning the Examiner's conclusion, however, that it would have been obvious to utilize the claimed precursor with the expectation of obtaining similar results as Vaartstra, Hintermaier, and Senzaki, Applicants respectfully assert that the Examiner has relied on impermissible hindsight reconstruction to arrive at this conclusion. As a matter of fact the invention is not solely directed toward the TBTDET precursor use but toward the combination of TBTDET use, and heating of the carrier material between 200°C and 400°C, and partial pressure of TBTDET greater than or equal to 25mTorr. This novel and non-obvious combination of process steps, as has been determined by the inventors through significant experimentation, allows the formation of good quality tantalum oxide layers. See the specification, page 4, lines 4-25, and page 6, lines 4-9. None of the cited references individually, nor any combination thereof, teaches, anticipates, or suggests, the presently claimed combination of process steps.

Moreover, none of the aforementioned cited references teach nor suggest the use of TBTDET, and even less the claimed combination. A person of ordinary skill in the art would not have been looking at TBTDET as a precursor for obtaining good quality tantalum oxide films because of bad experimental results as discussed in the present specification, such as on page 4, lines 4-25.

Furthermore, the person of ordinary skill in the art would not have been motivated to use the claimed deposition parameters since deposition methods disclosed in the three cited references are different enough from each other such that the person of ordinary skill in the art would not have been motivated to modify them to obtain those novel process steps of the presently claimed invention. At last, the quality of the tantalum film oxide obtained in those prior-art documents is not in par with the one obtained through the use of the present invention. As a matter of fact, both Senzaki and Vaartstra require a post-deposition annealing of the tantalum oxide film to improve its structure and properties. By contrast no post-deposition treatment is required in the presently claimed invention for obtaining a good quality deposition. Lastly, no quality information is disclosed in Hintermaier.

Accordingly, in view of the amendments and remarks above, since Vaartstra, Hintermaier, or Senzaki, or any combination of the cited references, does not teach, anticipate, or suggest, the presently claimed combination of process steps as recited for independent Claim 1, and for all of the dependent Claims 2-15 and 40, that depend from the independent claim, Applicants believe that the rejection of Claims 1-15, under 35 U.S.C. 103(a) has been overcome. The Examiner should withdraw the rejection of these claims and allow Claims 1-15 and 40 to issue in a patent.

Conclusion

The foregoing is submitted as full and complete response to the Official Action mailed June 7, 2006, and it is submitted that Claims 1-15 and 40 are in condition for allowance. Reconsideration of the rejection is requested. Allowance of Claims 1-15 and 40 is earnestly solicited.

No amendment made was related to the statutory requirements of patentability unless expressly stated herein. No amendment made was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein that such amendment was made to distinguish over a particular reference or combination of references.

Applicants acknowledge the continuing duty of candor and good faith to disclose information known to be material to the examination of this application. In accordance with 37 CFR § 1.56, all such information is dutifully made of record. The foreseeable equivalents of any territory surrendered by amendment are limited to the territory taught by the information of record. No other territory afforded by the doctrine of equivalents is knowingly surrendered and everything else is unforeseeable at the time of this amendment by the Applicants and the attorneys.